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Original article

Clinical implications of and factors influencing dissociated pulmonary vein potentials

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ABSTRACT

Background: Factors influencing dissociated pulmonary vein (PV) potentials (DPVPs) in atrial fibrillation (AF) patients undergoing circumferential PV isolation have not been investigated. Furthermore, the clinical implications of such DPVPs remain controversial.

Methods: Circumferential PV isolation as a first ablation procedure was performed in 688 consecutive patients with AF (460 men; mean age, 58.9 ± 10.5 years). The clinical implications of and factors influencing DPVPs were evaluated.

Results: Acute PV isolation was achieved in 679 (98.7%) patients. A total of 578 (42.6%) ipsilateral PVs with DPVPs were documented in 378 (55.7%) patients (DPVPs group). Multivariate analysis revealed that male gender [odds ratio (OR): 1.894; 95% confidence interval (CI): 1.344–2.667; $p < 0.001$] and paroxysmal AF (OR: 1.715; 95% CI: 1.182–2.488; $p = 0.005$) were independent factors for DPVPs. The incidence of acute and intraoperative PV reconnection (PVR) was higher in the DPVPs group than in the non-DPVPs group (33.1% vs. 17.9%; $p < 0.001$ and 44.4% vs. 28.2%; $p < 0.001$). After the first procedure, 244 (65.6%) DPVPs-group patients and 168 (56.4%; $p = 0.015$) non-DPVPs group patients were free from AF recurrence. During repeat procedures, PVR incidence was similar in the DPVPs group (81.8%) and non-DPVPs groups (83.3%; $p = 0.863$).

Conclusion: Male gender and paroxysmal AF were independent risk factors for DPVPs in patients undergoing circumferential PV isolation. DPVPs had a significant impact on acute and intraoperative PVR. The outcomes of the first ablation procedure were better in patients with DPVPs.

Introduction

Electrical isolation of the pulmonary veins (PVs) has been considered the cornerstone of catheter ablation for the treatment of atrial fibrillation (AF) [1–4]. Dissociated PV potentials (DPVPs) of a primarily slow and repetitive nature within the PVs, a demonstration of PV exit block and entrance block, are accepted as a sign of electrical disconnection of the PVs from the left atrium (LA) during PV isolation [5,6]. The incidence of DPVPs during PV isolation ranges from 9% following segmental isolation to 40% following antral isolation [5,7]. Studies have suggested that PVs with DPVPs, or arrhythmogenic PVs, are more likely to have an extensive connection with the LA and be associated with early AF recurrence [8–10]. However, apart from the type of procedure, factors that influence the occurrence of DPVPs have not been investigated. Furthermore, the impact of such DPVPs on PV reconnection (PVR) remains controversial and has not been systematically assessed in a large sample. Therefore, in this study, we identified the factors that influence the occurrence of DPVPs and evaluated the clinical implications of such DPVPs in AF patients who underwent circumferential PV isolation as a first ablation procedure.

Methods

Study population

The study population consisted of 688 consecutive patients (460 men; mean age, 58.9 ± 10.5 years) with paroxysmal or

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persistent (including long-standing persistent), drug-refractory AF who were scheduled to undergo their first ablation procedure between February 2007 and January 2011. Paroxysmal and persistent AF were defined according to the expert consensus statement [4]. Written informed consent was obtained from every patient.

Preoperative preparation and ablation procedure

The preoperative preparation has previously been described in detail [11,12]. The ablation procedure was performed while patients were under sedation with a bolus of midazolam and analgesia with a continuous infusion of fentanyl [11].

The protocol of AF ablation has previously been described in detail [11,12]. A multipolar electrode 6F catheter was positioned in the coronary sinus (CS). A transseptal puncture was performed, and two long sheaths were placed in the LA. Electroanatomical mapping and ablation were performed with a 3.5-mm-tip catheter (ThermoCool Navi-Star, Biosense Webster, Diamond Bar, CA, USA). Image integration with the reconstructed computed tomography scan was performed. Circumferential PV isolation was performed just outside the ostia of the ipsilateral PVs. A circular mapping catheter (Lasso, Biosense Webster) was placed within the superior or inferior PV or within the branches of a common PV to identify the breakthrough region of the LA to PV conduction and to guide gap ablation for PV isolation. If AF persisted, linear ablation and complex fractionated atrial electrogram ablation were performed if necessary. Electrical or drug cardioversion was attempted to restore sinus rhythm when AF termination could not be achieved with the abovementioned steps. After cardioversion, bidirectional conduction block of all the ablation lines was checked, and reinforcement ablation was performed, if necessary, to confirm the bidirectional conduction block.

Irrigated radiofrequency energy was delivered with an upper temperature limit of 43 °C, a maximum radiofrequency power of 38 W and an infusion rate of 17–25 ml/min. In all patients, the maximal power delivered to the superior vena cava and the CS was set at 25 W, to minimize the risk of cardiac tamponade or phrenic nerve impairment. The maximal power delivered to the posterior wall was set at 35 W, to minimize the risk of esophageal injury.

Identification and evaluation of DPVPs and PVR

Immediately after the ipsilateral PVs were isolated, the electrical activities in the isolated veins were assessed by placing the Lasso catheter within each PV of the ipsilateral PVs for 5 min in each PV. After placement and stabilization of the Lasso catheter, the 5-min recording period was started, and the Lasso catheter was not moved during this period. DPVPs were defined as sharp and high-frequency potentials that were not associated with the far-field atrial potentials or with manipulation of the catheters (Fig. 1). For paroxysmal AF, isoproterenol was used to detect DPVPs after PV isolation during the initial procedure. Patients with DPVPs were assigned to the DPVPs group and those without such DPVPs were assigned to the non-DPVPs group.

After the recording period, the Lasso catheter was placed within the PVs (in the PVs with more frequent DPVPs if more than one ipsilateral vein had DPVPs, or in the superior PV if no DPVPs were documented in the ipsilateral PVs) for at least 30 min (including the 5 min observation period for each PV in the ipsilateral PVs) to evaluate and document the DPVPs and PVR (Fig. 2). Acute PVR was defined as re-conduction with the LA within 30 min after isolation. Intraoperative PVR was defined as PVR occurring during the ablation procedure, including acute PVR. The timing of PVR was also documented.

For those patients who underwent a repeat procedure for recurrent atrial arrhythmias, the presence or absence of DPVPs was

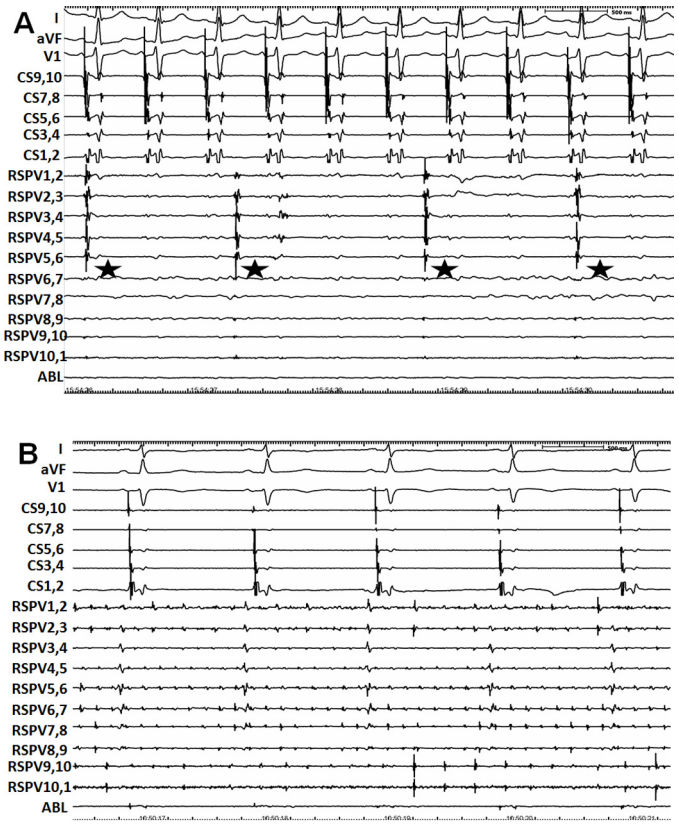

Fig. 1. Identification of spontaneous activities (dissociated pulmonary vein potentials; DPVPs). Tracings were obtained using surface electrocardiographic (ECG) leads I, aVF, V1. Intracardiac electrograms were recorded using a coronary sinus catheter (CS1,2 to CS9,10), a Lasso catheter within the right superior pulmonary vein (RSPV1,2 to RSPV10,1), and the distal pair electrodes of an ablation catheter (ABL). DPVPs were defined as sharp and high-frequency potentials that were not associated with far-field atrial potentials or catheter manipulation. Panel A: Repetitive DPVPs (★) from the RSPV were recorded after circumferential pulmonary vein isolation in a patient. Panel B: Sustained fibrillatory activities were documented from the RSPV after circumferential pulmonary vein isolation in another patient.

Fig. 2. Illustration of pulmonary vein (PV) reconnection in a patient with spontaneous activities (dissociated pulmonary vein potentials; DPVPs) in the PVs. Tracings were obtained using surface electrocardiographic leads I, aVF, V1. Intracardiac electrograms were recorded using a coronary sinus catheter (CS1,2 to CS9,10), a Lasso catheter within the left superior PV (LSPV1,2 to LSPV10,1) and the distal pair of electrodes of an ablation catheter (ABL). Repetitive DPVPs (★) were recorded from the LSPV after circumferential PV isolation in a patient. Interestingly, during the 30-min observation period, PV reconnection with the left atrium (LA) was documented as PV potentials (↑) conducted from the LA. Note that the activation sequence of the DPVPs was different from that of the PV potentials conducted from the LA.

also recorded after re-isolation. Moreover, isoproterenol was used for detecting DPVPs and inducing atrial arrhythmia after the PV isolation. Chronic PVR was defined as PVR with the LA at the beginning of the repeat procedure.

Follow-up

After the procedure, all patients were asked to participate in periodic follow-up in an outpatient clinic and via telephone interviews. The presence/absence of AF was evaluated on the basis of their symptoms, electrocardiographic recordings, and 24-h ambulatory monitoring. Freedom from AF recurrence was defined as no AF (symptomatic and asymptomatic AF episodes) or arrhythmia recurrence (including atrial tachycardia and atrial flutter) lasting less than 30 s in patients not receiving antiarrhythmic drugs, after a blanking period of 3 months. The protocol of follow-up has previously been described in detail [11,12].

Statistical analysis

Continuous variables are expressed as mean and standard deviation. Discrete variables are presented as percentages. Baseline characteristics of the patients were compared between the two groups to determine the factors influencing DPVPs. An independent samples *t*-test was performed to evaluate between-group differences in continuous variables, while the Fisher exact test or χ^2 test was used for categorical variables. Logistic regression analysis was performed to identify independent risk factors for DPVPs. All tests were two-tailed. A *p*-value of <0.05 was considered statistically significant. Statistical analyses were performed using the SPSS 17.0 software package (SPSS Inc., Chicago, IL, USA).

Results

Ablation results and complications

Circumferential PV isolation was performed successfully in 679 patients. In the remaining nine patients, one ipsilateral PV continued to have significantly delayed PV potentials. Thus, the acute success rate of PV isolation was 98.7%.

In the study population, a total of 38 (5.6%) complications were encountered. There were 15 vascular access-related complications (10 femoral hematomas, 3 femoral arterio-venous fistulas and 2 femoral pseudo-aneurysms), which were managed conservatively. In addition, there occurred one pneumothorax and three cerebral infarctions, which were also managed conservatively, without any sequelae. Moreover, there were 10 pericardial effusions (all managed conservatively without any sequelae) and 9 pericardial tamponades (resolved by pericardiopuncture in five patients and by surgical drainage in four patients). There were no other major complications.

Incidences and influence factors of DPVPs

DPVPs were documented in 578 of 1358 ipsilateral PVs (42.6%; 294 left PVs and 284 right PVs) in 378 of the 679 patients (55.7%; 200 with both sides; DPVPs group). The incidence of DPVPs did not significantly differ between patients with DPVPs in the left PVs and those with DPVPs in the right PVs (43.3% vs. 41.8%; $p = 0.583$). In our study, DPVPs were classified into two types: ectopic rhythm (regular or irregular) and fibrillatory activities. Fibrillatory activities were documented in 35 of 578 ipsilateral PVs (6.1%; 21 left PVs and 14 right PVs) in 32 of 378 patients (8.5%; 3 with both sides). The incidence of fibrillatory activities was similar in the left and right PVs (7.1% vs. 4.9%; $p = 0.265$).

Comparisons between the DPVPs and non-DPVPs groups are shown in Table 1. Univariate analysis revealed that gender ($p < 0.001$), rheumatic heart disease (RHD; $p < 0.001$), history of cardiac surgery ($p < 0.001$), type of AF ($p = 0.001$), LA diameter ($p = 0.006$), and preoperative amiodarone therapy ($p = 0.024$) significantly differed between the DPVPs and non-DPVPs groups. Multivariate analysis revealed that male gender [odds ratio (OR): 1.894; 95% confidence interval (CI): 1.344–2.667; $p < 0.001$] and paroxysmal AF (OR: 1.715; 95% CI: 1.182–2.488; $p = 0.005$) were independently associated with the presence of DPVPs.

Interestingly, age ($p < 0.001$), comorbidities ($p = 0.002$; especially RHD and diabetes mellitus), history of cardiac surgery ($p = 0.001$) and type of AF ($p = 0.004$) significantly differed between male and female patients (Table 2).

Incidence of acute and intraoperative PVR

During the 30-min observation and evaluation period, acute PVR occurred in 205 of 1358 ipsilateral PVs (15.1%; 110 left PVs and 95 right PVs) in 179 of 679 patients (26.4%), at a mean of 17.1 ± 9.6 min after isolation. After this 30-min period, PVR was observed in an additional 97 ipsilateral PVs (7.1%; 46 left PVs and 51 right PVs) in 74 patients (10.9%), at a mean of 54.8 ± 30.8 min after isolation. Thus, intraoperative PVR was observed in 302 ipsilateral PVs (22.2%; 156 left PVs and 146 right PVs) in 253 patients (37.3%), at 25.6 ± 23.1 min after isolation.

The incidence of acute and intraoperative PVRs was higher in the DPVPs group than in the non-DPVPs group (33.1% vs. 17.9%; $p < 0.001$ and 44.4% vs. 28.2%; $p < 0.001$, respectively; Table 3). However, the timing of acute and intraoperative PVRs did not significantly differ between the two groups (Table 3). The incidence of acute and intraoperative PVR was similar in the left and right PVs (acute PVR: 16.2% vs. 14.0%; $p = 0.256$; intraoperative PVR: 23.0% vs. 21.5%; $p = 0.514$). Moreover, the incidence of acute and intraoperative PVRs was similar in DPVPs present with

Table 1
Comparison between the DPVPs group and the non-DPVPs group.

Factors	DPVPs group $N = 378$	Non-DPVPs group $N = 301$	*p*-value
Male, *n* (%)	276 (73.0)	179 (59.5)	<0.001
Age, years	58.4 ± 10.6	59.4 ± 10.5	0.200
Type of AF			
Paroxysmal, *n* (%)	261 (69.0)	169 (56.1)	0.001
Non-paroxysmal, *n* (%)	117 (30.9)	132 (43.9)	0.001
History of AF, months	74.5 ± 74.0	75.1 ± 75.5	0.923
Body mass index, kg/m^2	24.7 ± 2.9	24.7 ± 3.0	0.978
Body surface area, m^2	1.78 ± 0.17	1.77 ± 0.19	0.350
Left atrium diameter, mm	41.5 ± 5.5	42.8 ± 6.5	0.006
Left ventricular ejection fraction, %	64.3 ± 5.5	64.0 ± 6.5	0.606
Comorbidities, *n* (%)	197 (52.1)	172 (57.1)	0.191
Hypertension, *n* (%)	184 (48.7)	152 (50.5)	0.637
Coronary heart disease, *n* (%)	9 (2.4)	4 (1.3)	0.320
Diabetes mellitus, *n* (%)	34 (9.0)	27 (9.0)	0.991
Cardiomyopathy, *n* (%)	4 (1.1)	7 (2.3)	0.230
Rheumatic heart disease, *n* (%)	2 (0.5)	14 (4.6)	<0.001
History of cerebral embolism, *n* (%)	20 (5.3)	18 (6.0)	0.698
History of cardiac surgery, *n* (%)	2 (0.5)	15 (5.0)	<0.001
Preoperative amiodarone, *n* (%)	73 (19.3)	80 (26.6)	0.024
Beta-receptor blocker, *n* (%)	135 (35.7)	113 (37.5)	0.623
Calcium channel blocker, *n* (%)	47 (12.4)	37 (12.3)	0.956

AF, atrial fibrillation; DPVPs, dissociated pulmonary vein potentials.

Table 2
Comparisons between male and female patients.

Factors	Male $N=455$	Female $N=224$	p-value
Age, years	57.6 ± 10.6	61.5 ± 10.0	<0.001
Type of AF			
Paroxysmal, n (%)	271 (59.6)	159 (71.0)	0.004
Non-paroxysmal, n (%)	184 (40.4)	65 (29.0)	0.004
History of AF, months	75.5 ± 78.3	73.2 ± 66.4	0.708
Body mass index, kg/m^2	25.0 ± 2.9	24.1 ± 3.1	0.001
Body surface area, m^2	1.85 ± 0.14	1.61 ± 0.13	<0.001
Left atrium diameter, mm	42.2 ± 6.0	41.9 ± 6.0	0.592
Left ventricular ejection fraction, %	64.0 ± 6.0	64.5 ± 6.1	0.279
Comorbidities, n (%)	228 (50.1)	141 (62.9)	0.002
Hypertension, n (%)	216 (47.5)	120 (53.6)	0.135
Coronary heart disease, n (%)	8 (1.8)	5 (2.2)	0.767
Diabetes mellitus, n (%)	28 (6.1)	33 (14.7)	<0.001
Cardiomyopathy, n (%)	7 (1.5)	4 (1.8)	0.758
Rheumatic heart disease, n (%)	3 (0.7)	13 (5.8)	<0.001
History of cerebral embolism, n (%)	22 (4.8)	16 (7.1)	0.219
History of cardiac surgery, n (%)	5 (1.1)	12 (5.4)	0.001
Preoperative amiodarone, n (%)	108 (23.7)	45 (20.1)	0.285
Beta-receptor blocker, n (%)	157 (34.5)	91 (40.6)	0.119
Calcium channel blocker, n (%)	55 (12.1)	29 (12.9)	0.749

AF, atrial fibrillation.

fibrillatory activities and with ectopic rhythm (37.5% vs. 32.7%; $p = 0.578$ and 43.7% vs. 44.5%; $p = 0.934$, respectively).

Interestingly, the fluoroscopy time of the DPVPs group was shorter than that of the non-DPVPs group (29.0 ± 11.7 min vs. 31.5 ± 12.6 min, $p = 0.033$). However, the total procedure time did not significantly differ between the two groups (4.80 ± 1.16 h vs. 4.90 ± 1.17 h, $p = 0.372$).

Follow-up results after the initial procedure

A total of nine patients (DPVPs group, six; non-DPVPs group, three; $p = 0.504$) died an average of 19.9 ± 18.4 months after their last ablation (none within 30 days of the procedure). Eight of these patients had undergone a single ablation, and one had had repeat ablations. Six were AF-free at the time of their deaths (these data were excluded in the analysis of AF recurrence). The cause of death was myocardial infarction in one patient, progressive heart failure in one patient, sudden death in two patients, non-cardiac death in four patients, and unknown in one patient.

Table 3
Impact of DPVPs on pulmonary vein reconnection (PVR) and clinical outcomes.

Factors	DPVPs group $N=378$	Non-DPVPs group $N=301$	p-value
Acute PVR, n (%)	125 (33.1)	54 (17.9)	<0.001
Time of acute PVR, min	16.4 ± 9.5	18.8 ± 9.7	0.114
Intraoperative PVR, n (%)	168 (44.4)	85 (28.2)	<0.001
Time of intraoperative PVR, min	25.4 ± 25.2	26.2 ± 17.6	0.796
Patients undergoing repeat procedures, n (%)	33 (8.9)	42 (14.1)	0.033
Chronic PVR at repeat procedure, n (%)	27 (81.8)	35 (83.3)	0.863
Single-procedure success[a], n (%)	244 (65.6)	168 (56.4)	0.015
Multiple-procedure success, n (%)	269 (72.3)	199 (66.8)	0.121

DPVPs, dissociated pulmonary vein potentials.
[a] For both single and multiple ablations, procedural success was defined as the absence of symptomatic atrial fibrillation (AF) or AF recurrences lasting for less than 30 s in patients not receiving antiarrhythmic drugs, after a blanking period of 3 months.

After the first procedure, 244 of the 372 patients (65.6%) in the DPVPs group were free of AF recurrence and maintained normal sinus rhythm without antiarrhythmic agents during a mean follow-up period of 32.5 ± 15.1 months. In contrast, freedom from AF recurrence after a single procedure was achieved in 168 of the 298 patients (56.4%) in the non-DPVPs group ($p = 0.015$, Table 3), during a mean follow-up period of 32.9 ± 13.6 months ($p = 0.778$).

Repeat procedure and follow-up results

In all, 75 patients (11.0%; DPVPs group, 33; non-DPVPs group, 42; $p = 0.033$; Table 3) underwent repeat ablation for recurrent atrial arrhythmias, 15.3 ± 11.2 months after the first ablation procedure. During the repeat procedure, the incidence of PVR was similar in the DPVPs group (81.8%, 27/33) and the non-DPVPs group (83.3%, 35/42, $p = 0.863$). The incidence of DPVPs at the repeat procedure was 72.7% (24/33) in the DPVPs group and 40.5% (17/42) in the non-DPVPs group ($p = 0.005$). After re-isolation, 70.0% (20/29) of the left ipsilateral PVs with DPVPs in the first ablation still presented with DPVPs. 58.3% (14/24) of the right ipsilateral PVs with DPVPs in the first ablation still presented with DPVPs.

After the last procedure (1.09 ± 0.28 times), 269 of the 372 patients (72.3%) in the DPVPs group were free of AF recurrence and maintained normal sinus rhythm without antiarrhythmic agents, during a follow-up period of 31.4 ± 15.2 months. Freedom from AF recurrence after multiple procedures (1.14 ± 0.36 times; $p < 0.001$) was achieved in 199 of the 298 patients (66.8%) in the non-DPVPs group ($p = 0.121$, Table 3), during a follow-up period of 30.4 ± 14.1 months ($p = 0.413$).

Furthermore, the success rate after the first procedure and after the last procedure was also similar in DPVPs present with fibrillatory activities and with ectopic rhythm (61.3% vs. 66.0%; $p = 0.598$ and 74.2% vs. 72.1%; $p = 0.807$, respectively). The detailed outcome data adjusted by AF type are manifested in the supplement Table S1 and Table S2.

Discussion

According to the literature, DPVPs within the PVs have been accepted as a sign of electrical disconnection from the LA during PV isolation [5,6]. Such DPVPs are of several types, including single ectopic, sustained PV rhythm, and PV fibrillation [6,13]. The incidence and characteristics of these DPVPs, most of which were slow and repetitive, have been extensively studied [5–7,10,11,13,14]. In our study, these DPVPs were defined as sharp and high-frequency potentials that were not associated with far-field atrial potentials or catheter manipulation. The incidence of DPVPs in the PVs reportedly varies with the operation strategy, from 9% following segmental isolation to 40% following antral isolation [5–7]. Differences in definition, study population and ablation approaches might account for these variations [14]. In our large sample population, DPVPs were observed after circumferential PV isolation in 42.6% ipsilateral PVs and in 55.7% patients, which were similar to the results of most other researches.

P cells, transitional cells, and Purkinje cells have been detected in human PVs [15]. Therefore, the PVs may have the property of autorhythmicity and may generate action potentials (DPVPs). Indeed, DPVPs have been commonly observed after the PVs were disconnected from the LA. The underlying mechanism may be that the electrical activities of the autorhythmic cells in the PVs were probably suppressed by a more rapid sinus rhythm. Consequently, the presence of DPVPs indicated that the target PV may be an arrhythmogenic PV and was isolated from the LA.

Although DPVPs have been observed in PVs, not all PVs show DPVPs. However, apart from the type of procedure, factors that influence the occurrence DPVPs in the PVs are not known. In contrast to previous studies, this study aimed to determine the factors that influence DPVPs. We found that male gender (OR: 1.894) and paroxysmal AF (OR: 1.715) were independently associated with the presence of DPVPs.

Focal firing in the PVs is known to trigger AF or act as a rapid driver to maintain AF [4]. The important role of PVs in paroxysmal AF has been proved by considerable evidence [16,17]. In the case of non-paroxysmal AF, however, several other mechanisms may maintain the AF [18]. Furthermore, compared to paroxysmal AF, persistent and long-standing persistent AF may result in more extensive remodeling of the LA and PVs [4]. We presumed that remodeling of the PVs and atria, including fibrosis, may attenuate or block the electrical activities of autorhythmic cells in the PVs. Therefore, we considered that after PV isolation, DPVPs would not appear as frequently in non-paroxysmal AF patients as in paroxysmal AF patients.

Ongoing electrical and structural remodeling of the atria due to aging, inflammation, and other comorbidities such as diabetes, may lead to progressive atrial electrical instability [4]. Interestingly, older age ($p < 0.001$), more comorbidities ($p = 0.002$; especially RHD and diabetes mellitus) and a higher prevalence of cardiac surgery history ($p = 0.002$) were found in the female patients in our study (Table 2). Therefore, remodeling of the atrium and PVs may have been more extensive or severe in the female patients. This remodeling may account for the lower incidence of DPVPs in the female patients, despite the higher incidence of paroxysmal AF ($p = 0.004$).

The clinical implications of DPVPs during circumferential PV isolation remain controversial [10,17,19]. In a study of 85 patients, the occurrence of dissociated PV rhythm after PV isolation was closely related to the acute PVR at 30 min after isolation [10]. Interestingly, this finding was substantiated in our large sample population. The incidence of acute and intraoperative PVR was higher in the DPVPs group than in the non-DPVPs group (acute PVR: 33.1% vs. 17.9%; $p < 0.001$; intraoperative PVR: 44.4% vs. 28.2%; $p < 0.001$). Considering that electrical activities are expected to be more frequent if the isolated muscular sleeve is large [14], PVs that show DPVPs may have a more circumferential and thicker muscular sleeve, which may be difficult to isolate and may facilitate re-conduction. Therefore, the occurrence of DPVPs after PV isolation was related to the incidence of acute and intraoperative PVR. However, the presence of DPVPs in the initial procedure did not affect the incidence of chronic PVR. This can be explained by the finding that most PVs are found to be reconnected with the LA during repeat procedures [20]. Therefore, the rate of chronic PVR did not significantly differ with the incidence of DPVPs, as illustrated by our data (81.8% in the DPVPs group vs. 83.3% in the non-DPVPs group, $p = 0.863$).

In a study of 89 patients, the presence of DPVPs did not predict recurrent AF following PV isolation (24% vs. 36%; $p = 0.30$) [19]. However, another study of 196 patients reported that dissociated PV electrical activities might identify a subgroup of patients with relatively higher initial procedural success after circumferential PV antrum ablation ($p = 0.023$) [17]. In our study, the occurrence of DPVPs resulted in a better outcome after the first procedure (65.6% vs. 56.4% in the non-DPVPs group, $p = 0.015$) but had no impact on the outcome after multiple procedures. The above results were further supported in the subgroup of patients with paroxysmal AF in our study. The different outcomes of the DPVPs and non-DPVPs groups after the first procedure may be explained by the following: (i) DPVPs appeared more frequently in those PVs without extensive or serious remodeling; therefore, a smaller arrhythmogenic substrate was encountered in patients with DPVPs. (ii) Patients without DPVPs might require additional ablation for non-PV foci. (iii) Since acute and intraoperative PVR was frequent in the DPVPs group, reinforcement ablation was performed to completely re-isolate the target PVs, and this may account for the higher success rate after the first procedure. (iv) More patients in the non-DPVPs group underwent repeat procedures (partly due to more patients with non-paroxysmal AF being present), which may have improved the clinical outcomes after multiple procedures.

In conclusion, male gender and paroxysmal AF independently influenced the occurrence of DPVPs in patients who underwent circumferential PV isolation. DPVPs had a significant impact on acute and intraoperative PVR. The outcomes of the first ablation procedure were better in patients with DPVPs than in the non-DPVPs patients.

Study limitations

In this study, due to economic reasons, a single Lasso catheter was used for each patient, and it was placed within one of the ipsilateral PVs. Therefore, the incidence of DPVPs may have been underestimated. The follow-up data were mainly based on periodic outpatient visits and telephone interviews. Continuous electrocardiographic monitoring was not systematically performed, as it was difficult to implant invasive, arrhythmia-monitoring devices in every patient. Although 24-h ambulatory monitoring is an effective method to identify frequent asymptomatic recurrences, some asymptomatic paroxysmal arrhythmia recurrences may have been missed. Thus, the true clinical success rate may have been overestimated. If the follow-up had included 7-day Holter monitoring or event recorders, the results might have been more accurate.

Disclosures

None.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.jjcc.2014.11.009.

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